NASA TECHNICAL MEMORANDUM

NASA TM X-71863

NASA TM X-71863

STANDARDIZED PERFORMANCE TESTS OF COLLECTORS OF SOLAR THERMAL ENERGY - PROTOTYPE MODERATELY CONCENTRATING GROOVED COLLECTORS

by Power Systems Division
Lewis Research Center
Cleveland, Ohio 44135

January 1976

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
NASA TM X-71863		

4. Title and Subtitle	5. Report Date
STANDARDIZED PERFORMANCE TESTS OF COLLECTORS OF SOLAR THERMAL ENERGY - PROTOTYPE MODERATELY CONCENTRATING GROOVED COLLECTORS	6. Performing Organization Code
7. Author(s) Power Systems Division	8. Performing Organization Report No. E-8626
9. Performing Organization Name and Address Lewis Research Center National Aeronautics and Space Administration Cleveland, Ohio 44135	10. Work Unit No. 11. Contract or Grant No.
12. Sponsoring Agency Name and Address National Aeronautics and Space Administration Washington, D.C. 20546	13. Type of Report and Period Covered Technical Memorandum 14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract

Prototypes of moderately concentrating grooved collectors were tested with a solar simulator for varying inlet temperature, flux level and incident angle. Collector performancs is correlated in terms of inlet temperature and flux level.

17. Key Words (Suggested by Author(s))	18. Distribution Statement
	Unclassified - unlimited

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price*
Unclassified	Unclassified		

* For sale by the National Technical Information Service, Springfield, Virginia 22161

STANDARDIZED PERFORMANCE TESTS OF COLLECTORS OF SOLAR THERMAL ENERGY - PROTOTYPE MODERATELY CONCENTRATING GROOVED COLLECTORS

Power Systems Division

Lewis Research Center

INTRODUCTION

An area presently being investigated by the NASA-Lewis Research Center in its efforts to aid in the utilization of alternate energy sources is the use of solar energy for the heating and cooling of buildings. An important part of this effort is the evaluation of solar collectors which have the potential to be efficient, economical, and reliable.

This preliminary data report gives basic test results of a collector whose performance was determined in the NASA-Lewis solar simulator. In the interest of providing performance data on this collector to the technical community as quickly as possible, the basic test results reported herein are presented without evaluation. Detailed analyses and interpretation of these results may be presented in subsequent papers or reports by this Center. Some of the results contained in this report may be changed as warranted by reviews and evaluations, or by obtaining additional data on this collector.

Reference 1 describes the solar-simulator test facility as well as the basic test procedure used in this test.

COLLECTOR DESCRIPTION

The collectors tested were made under contract to National Science Foundation at the University of Houston, Houston, Texas (Ref. 2).

Four prototype liquid-heating solar-energy collectors were built for evaluation of the grooved collector concept and to compare performance with comparable flat-plate collectors.

The four collector assemblies are exactly the same (fiber glass box, insulation, and cover-glass assembly) except for the absorber plate coatings and the presence or absence of the grooves. While a roll-bond aluminum panel is used as the absorber plate in all four collectors, the panel in two of the collectors is painted with a nonselective black paint and the panel in the other two is plated with the Honeywell black-nickel selective surface. In two of the collectors, one with each type of

absorber surface, ordinary glass back-surface mirrors are used to form the sidewalls of the trapezoidal grooves. These mirrors are attached directly to the roll-bond panel. The mirrors are supported by teflon wedges screwed to the panel. Aluminum clips hold the mirrors in place. The groove opening angle is 30° with a width-to-base ratio of 1.93, an absorbing surface width of 1.44 inches and a mirror width of 2.5 inches. A photograph of the collector on the test stand is shown in figure 1.

Each collector is contained in a 54" by 24" by 8" fiber-glass box, open at the top. The box has a false bottom 3 inches from the top lid. Through access holes in the bottom, a four-inch bat of glass-wool insulation is inserted between the false bottom and the true bottom. The roll-bond panels are attached directly to the false bottom. They are cushioned and further insulated with an additional one-inch layer of insulation. A double-glass panel is mounted on top of the collector box and is secured with stainless steel clips.

COLLECTOR TEST RESULTS

Basic test results are given in Tables IA-ID and Figures 2A-2D.

REFERENCES

1. Simon, F. F.: Flat-Plate Collector Performance Evaluation with a Solar Simulator as a Basis for Collector Selection and Performance Prediction, paper presented at the 1975 International Solar Energy Society Meeting, Los Angeles, California, July 28-August 1, 1975, NASA TMX-71793.

2. Howell, John R. and Bannerot, Richard B.: The Evaluation of Surface Geometry Modification to Improve the Performance of Solar Energy Collectors, Technical Report NSF/RANN/ SE/GI-41003/TR/74/1, 1974.

TABLE I - BASIC EXPERIMENTAL DATA

50/50 Water and Ethylene Glycol
Incident Angel = 0°
Tilt Angle = 57° Above Horizontal

Flow Per Radiated Surface Area lb/hr ft^2	Flow Gal/Min	Incident Radiation Flux Btu/hr ft^2	Fluid Outlet Temp.,°F	Fluid Inlet Temp.,°F	Ambient Temp.	Efficiency
10.386	0.11662	267.03	109.60	91.952	92.273	0.56711
10.416	0.11695	265.23	109.71	91.947	92.297	0.57635
10.530	0.11823	268.90	109.84	91.881	92.319	0.58126
10.078	0.11274	176.69	129.39	121.89	88.319	0.35871
10.573	0.11828	186.14	129.42	121.87	88.351	0.35992
10.456	0.11697	190.68	129.41	122.00	88.453	0.34094
10.413	0.11655	271.56	134.66	122.05	89.791	0.40630
10.683	0.11960	268.67	135.06	122.40	90.007	0.42319
10.624	0.11894	271.56	135.11	122.59	89.969	0.41167
9.9789	0.11476	185.91	165.86	160.04	87.039	0.26807
10.018	0.11522	187.39	165.84	160.07	87.139	0.26444
10.098	0.11615	187.32	165.86	160.23	87.220	0.26030
9.8382	0.11310	269.53	171.42	160.22	88.022	0.35149
9.8932	0.11373	270.31	171.40	160.19	87.934	0.35243
9.9477	0.11435	273.04	171.41	160.09	88.008	0.35427
9.8738	0.11374	179.19	199.32	197.44	90.053	0.90869E-01
9.9412	0.11452	180.91	199.50	197.48	90.157	0.97096E-01
9.9426	0.11453	182.16	199.57	197.39	90.173	0.10417
9.7370	0.11225	254.13	205.38	197.40	91.151	0.26802
9.5614	0.11022	254.05	205.46	197.78	91.271	0.25351
9.9273	0.11444	254.83	205.57	197.49	91.303	0.27617

A. Nonselective Black Paint - 2 glass

TABLE I - BASIC EXPERIMENTAL DATA

50/50 Water and Ethylene Glycol
Incident Angel = 0°
Tilt Angle = 57° Above Horizontal

Flow Per Radiated Surface Area lb/hr ft^2	Flow Gal/Min	Incident Radiation Flux Btu/hr ft^2	Fluid Outlet Temp.,°F	Fluid Inlet Temp.,°F	Ambient Temp.	Efficiency
11.616	0.11921	197.73	101.38	89.889	90.385	0.55615
11.616	0.11921	197.73	101.38	89.889	90.385	0.55615
11.616	0.11921	197.73	101.38	89.889	90.385	0.55615
11.616	0.11921	197.73	101.38	89.889	90.385	0.55615
11.629	0.11936	282.81	106.77	90.253	90.808	0.56045
11.629	0.11936	282.81	106.77	90.253	90.808	0.56045
10.975	0.11564	198.57	130.33	122.27	92.855	0.37390
10.975	0.11564	198.57	130.33	122.27	92.855	0.37390
10.975	0.11564	198.57	130.33	122.27	92.855	0.37390
10.975	0.11564	198.57	130.33	122.27	92.855	0.37390
10.975	0.11564	198.57	130.33	122.27	92.855	0.37390
10.975	0.11564	198.57	130.33	122.27	92.855	0.37390
10.649	0.11220	200.11	163.18	158.67	92.350	0.20536
10.649	0.11220	200.11	163.18	158.67	92.350	0.20536
10.649	0.11220	200.11	163.18	158.67	92.350	0.20536
10.649	0.11220	200.11	163.18	158.67	92.350	0.20536
10.649	0.11220	200.11	163.18	158.67	92.350	0.20536
10.840	0.11416	289.35	168.85	158.15	93.320	0.34403
10.840	0.11416	289.35	168.85	158.15	93.320	0.34403
10.563	0.11222	292.58	205.10	198.55	92.660	0.20746
10.563	0.11222	292.58	205.10	198.55	92.660	0.20746

B. Nonselective Black Paint 2 glass, mirrors

TABLE I - BASIC EXPERIMENTAL DATA

50/50 Water and Ethylene Glycol
Incident Angel = 0°
Tilt Angle = 57° Above Horizontal

Flow Per Radiated Surface Area lb/hr ft^2	Flow Gal/Min	Incident Radiation Flux Btu/hr ft^2	Fluid Outlet Temp.,°F	Fluid Inlet Temp.,°F	Ambient Temp.	Efficiency
10.610	0.11903	194.02	98.206	88.528	84.072	0.43535
10.610	0.11903	194.02	98.206	88.528	84.072	0.43535
10.610	0.11903	194.02	98.206	88.528	84.072	0.43535
10.713	0.12024	284.82	104.15	88.687	84.612	0.47951
10.713	0.12024	284.82	104.15	88.687	84.612	0.47951
10.713	0.12024	284.82	104.15	88.687	84.612	0.47951
9.7277	0.11227	198.39	128.29	117.64	85.359	0.43709
9.7277	0.11227	198.39	128.29	117.64	85.359	0.43709
9.7277	0.11227	198.39	128.29	117.64	85.359	0.43709
9.7277	0.11227	198.39	128.29	117.64	85.359	0.43709
9.7395	0.11242	289.81	137.31	120.03	87.140	0.48809
9.7395	0.11242	289.81	137.31	120.03	87.140	0.48809
9.7395	0.11242	289.81	137.31	120.03	87.140	0.48809
9.8457	0.11373	194.71	174.26	167.71	88.771	0.28570
9.8457	0.11373	194.71	174.26	167.71	88.771	0.28570
9.8457	0.11373	194.71	174.26	167.71	88.771	0.28570
9.7351	0.11247	291.42	180.98	167.68	88.887	0.38365
9.7351	0.11247	291.42	180.98	167.68	88.887	0.38365
9.7351	0.11247	291.42	180.98	167.68	88.887	0.38365
9.7557	0.11284	196.86	202.67	199.17	89.744	0.15175
9.7557	0.11284	196.86	202.67	199.17	89.744	0.15175
9.7557	0.11284	196.86	202.67	199.17	89.744	0.15175
9.6836	0.11203	284.36	207.22	198.28	90.908	0.26706
9.6836	0.11203	284.36	207.22	198.28	90.908	0.26706

C. Selective Black Nickel 2 glass

TABLE I - BASIC EXPERIMENTAL DATA

50/50 Water and Ethylene Glycol
Incident Angel = 0°
Tilt Angle = 57° Above Horizontal

Flow Per Radiated Surface Area lb/hr ft^2	Flow Gal/Min	Incident Radiation Flux Btu/hr ft^2	Fluid Outlet Temp.,°F	Fluid Inlet Temp.,°F	Ambient Temp.	Efficiency
10.365	0.10851	196.86	101.59	92.198	90.125	0.40751
10.365	0.10851	196.86	101.59	92.198	90.125	0.40751
10.365	0.10851	196.86	101.59	92.198	90.125	0.40751
10.393	0.10881	291.27	106.38	91.731	91.147	0.43158
10.393	0.10881	291.27	106.38	91.731	91.147	0.43158
10.393	0.10881	291.27	106.38	91.731	91.147	0.43158
10.427	0.10902	201.08	130.09	122.08	91.729	0.34835
10.427	0.10902	201.08	130.09	122.08	91.729	0.34835
10.427	0.10902	201.08	130.09	122.08	91.729	0.34835
10.415	0.10895	288.27	133.74	121.72	91.205	0.36480
10.415	0.10895	288.27	133.74	121.72	91.205	0.36480
10.415	0.10895	288.27	133.74	121.72	91.205	0.36480
10.415	0.10895	288.27	133.74	121.72	91.205	0.36480
9.9171	0.10536	293.41	132.26	119.63	87.839	0.35830
9.9171	0.10536	293.41	132.26	119.63	87.839	0.35830
9.9171	0.10536	293.41	132.26	119.63	87.839	0.35830
10.043	0.10665	200.16	170.96	166.75	89.394	0.18154
10.043	0.10665	200.16	170.96	166.75	89.394	0.18154
10.043	0.10665	200.16	170.96	166.75	89.394	0.18154
9.9994	0.10618	298.09	177.07	166.46	90.661	0.30688
9.9994	0.10618	298.09	177.07	166.46	90.661	0.30688
9.9994	0.10618	298.09	177.07	166.46	90.661	0.30688
9.9443	0.10557	293.26	209.66	201.86	91.502	0.23231
9.9443	0.10557	293.26	209.66	201.86	91.502	0.23231
9.9443	0.10557	293.26	209.66	201.86	91.502	0.23231

D. Selective Black Nickel 2 glass, mirrors

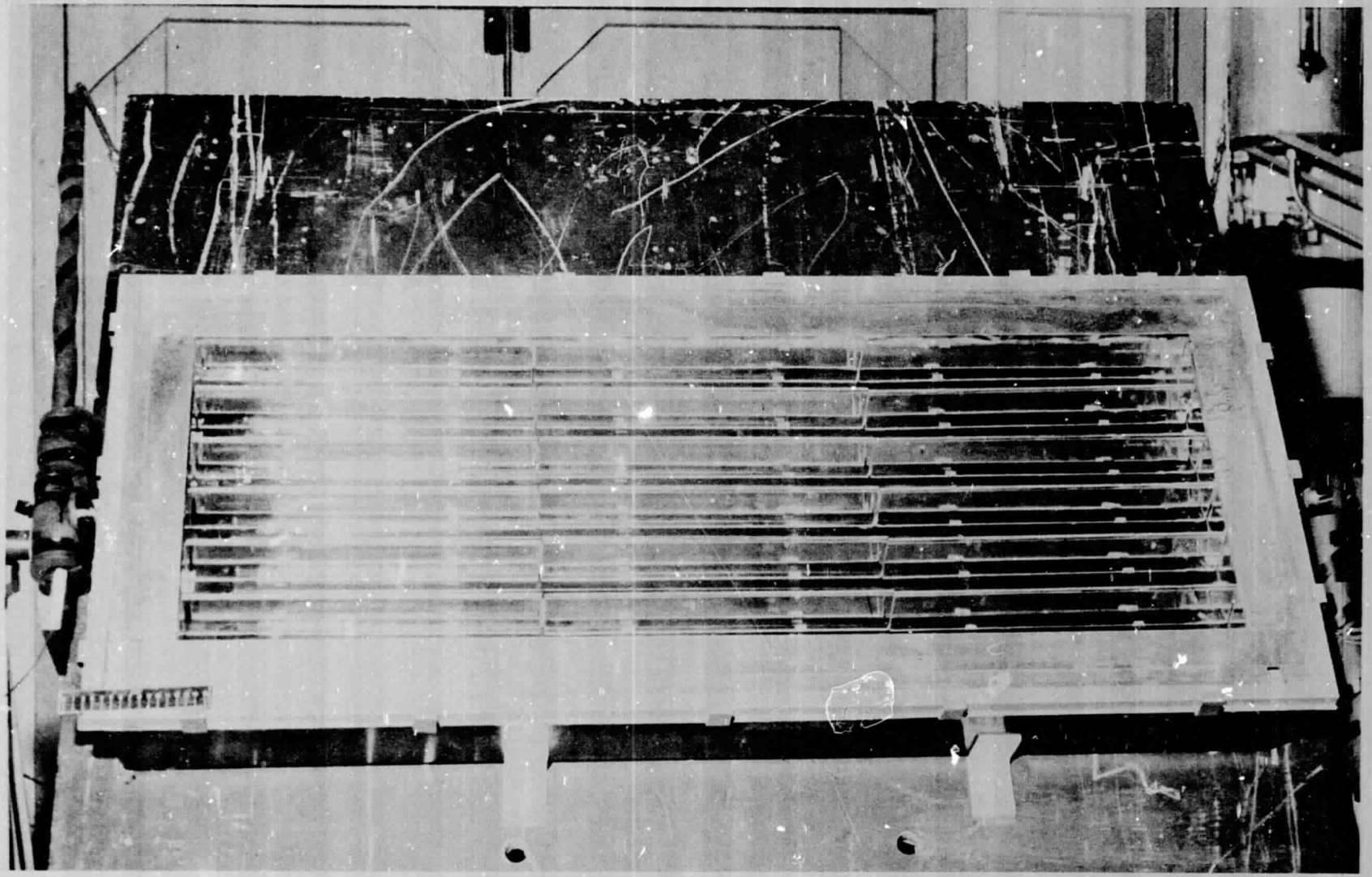

Figure 1. - Collector on Test Stand

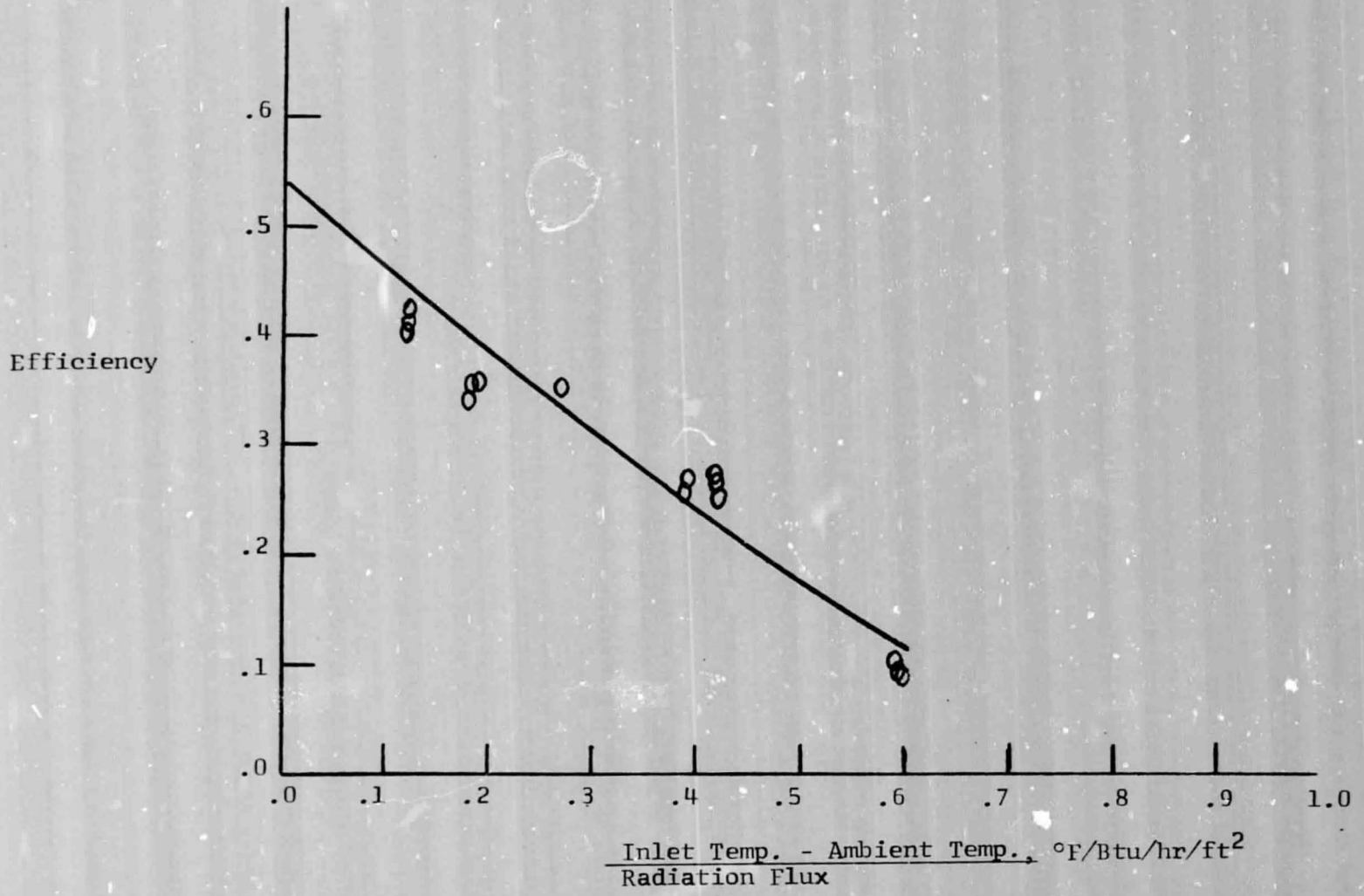

Figure 2A. - Nonselective Black Paint 2 Glass

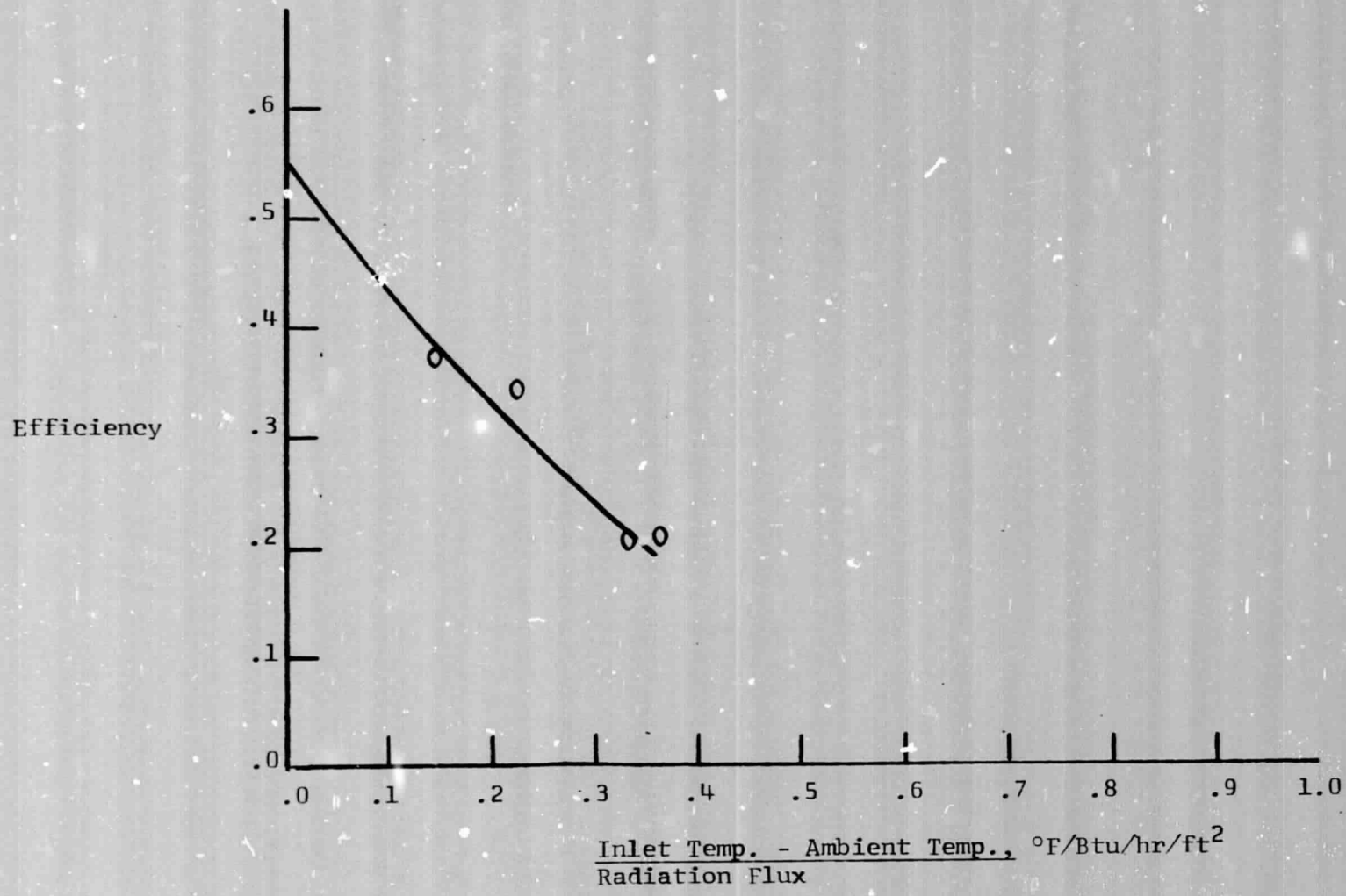

Figure 2B.- Nonselective Black Paint 2 Glass, Mirrors

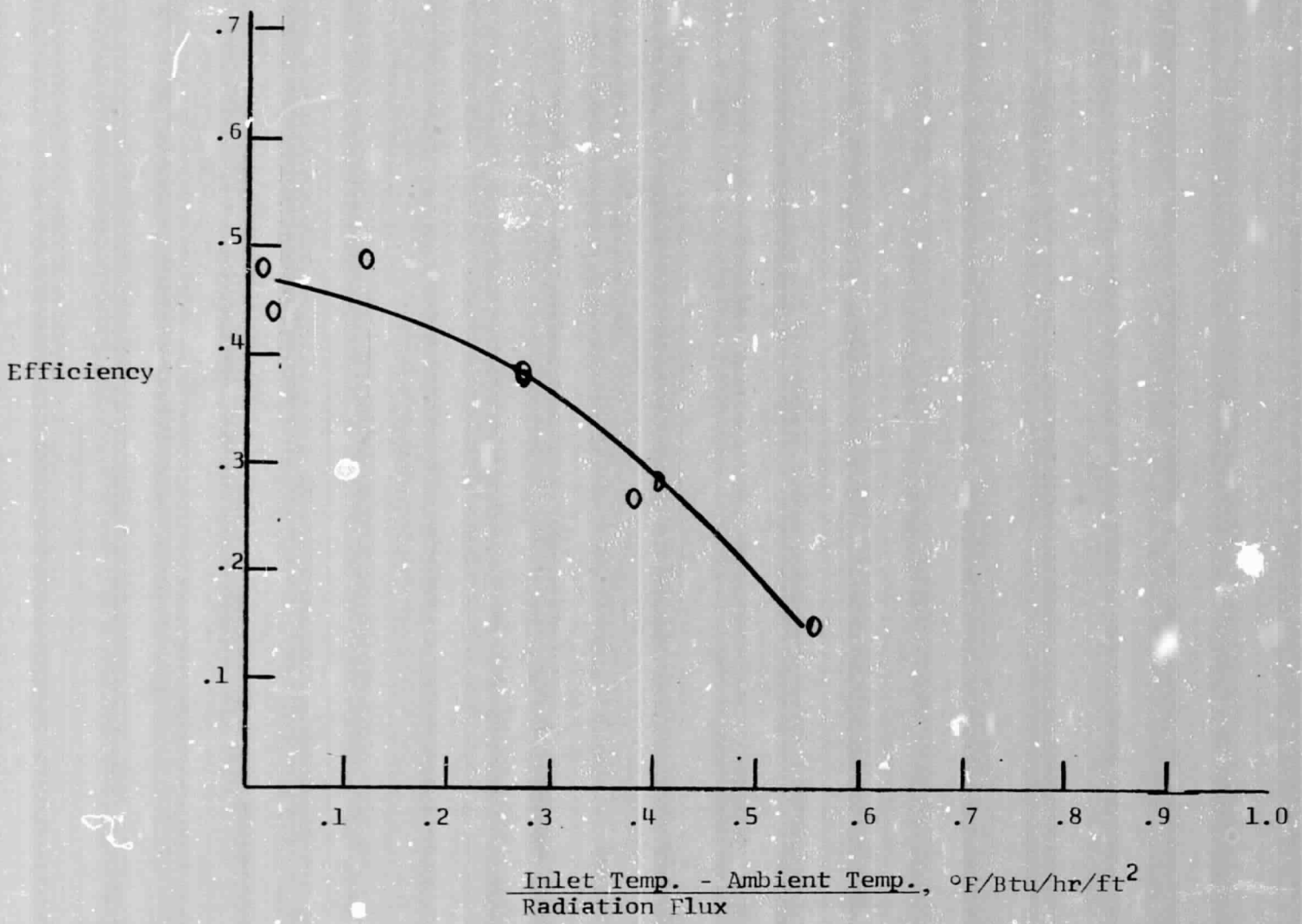

Figure 2C. - Selective Black Nickel 2 Glass